Ministry of
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Ontario

REPORT EM- 54

ONE POINT PROCTOR TEST
DETERMINATION OF MOISTURE DENSITY RELATIONSHIPS USING A FAMILY OF PROCTOR CURVES

Engineering
Materials
Office

ONE POINT PROCTOR TEST

DETERMINATION OF MOISTURE DENSITY RELATIONSHIPS

USING A FAMILY OF PROCTOR CURVES

by

A. K. Barsvary, P. Eng.

and

P. Korgemagi, P. Eng.

SOILS AND AGGREGATES SECTION
ENGINEERING MATERIALS OFFICE

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ONE POINT PROCTOR TEST
DETERMINATION OF MOISTURE-DENSITY RELATIONSHIPS
USING A FAMILY OF PROCTOR CURVES

(1) General

The One Point Proctor Test (abbreviated: OPT) determination of maximum density and optimum moisture content is a short-cut method for establishing a target density for compacted soils including base and sub-base aggregates. Because of the simplicity and time saved, this method should be used during construction, when a laboratory Proctor test result is not available for the particular soil being compacted. The resulting maximum dry density and optimum moisture content are to be used in computing the degree of compaction of the tested material.

The OPT method utilizes a family of typical Proctor dry density versus moisture content curves, developed for cohesive and non-cohesive soils in Ontario (Fig. 1, 2 & 3). The field wet density is determined by compacting the soil in a 152.4 mm (6 in.) diameter standard Proctor mold. The moisture content should be established by oven drying a sample. When the test is performed right on the jobsite it may be determined by a nuclear gauge. Care should be taken to measure the moisture content as close as possible to the compaction sample location. The nuclear gauge should be used after the material has been at least partially compacted. The dry density is computed from the wet density and moisture content. The values of dry density and moisture content determine a point on the set of proctor curves, from which the corresponding maximum dry density and optimum moisture content can easily be read.

There are two methods of compaction control used routinely by M.T.C. field inspectors, the constant dry weight (CDW) and the nuclear gauge methods. Since the CDW method

establishes the maximum density, no Proctor test is necessary. The OPT method can therefore be used on those contracts, where compaction checking is carried out by the nuclear gauge.

In order to plot the density and moisture content on the set of curves the material must have moisture contents within a certain range of the optimum. This range is typically from 5% below to 1 or 2% above the optimum. Most soils and processed aggregates will be within this range when used on construction. In very few cases it might be found that the moisture content of the tested soil plots outside the range of the curves. On such occasions water will have to be added if too dry, or the sample dried out if too wet. If the in-place water content was modified for the tests, the nuclear gauge value can no longer be used. The moisture content of the test portion should then be determined by conventional drying methods again.

The compaction of the soil into the mold may be done at the construction site, provided that a suitable level and firm surface such as asphalt or concrete is available. If a field laboratory is near the sampling location, it is the preferred practice that the test be performed in the laboratory on a solid concrete base.

Particles larger than about 25 mm (roughly 1 in.) should be discarded from the test portion and replaced by an equal mass of particles near to but smaller than 25 mm. While the 152.4 mm (6 in.) mold is recommended for the compaction test, the 101.6 (4 in.) diameter mold may be used for testing fine grained soils (silts and clays) and for sands containing less than 5% gravel (particles larger than approximately 5 mm).

(2) Family of Proctor Curve Diagrams

Proctor curve diagrams were developed separately for cohesive and non-cohesive materials. Since the character-

istics of non-cohesive materials in Northwestern Ontario are somewhat different from the rest of the province, non-cohesive curves were developed specifically for this region.

(2.1) Typical Moisture Density Curves for Non-Cohesive Soils in Ontario (See Figure 2, Imperial Units, and Figure 3, Metric)

This set of curves should be used to determine the maximum dry density and optimum moisture content for all granular base and subbase materials, all coarse grained soils, except those having more than 12% plastic fines (GC & SC), and for non-plastic silts (ML).

(2.2) Typical Moisture Density Curves for Cohesive Soils in Ontario (See Figure 1)

This set of curves should be used for coarse grained soils having more than 12% plastic fines (GC & SC) and for all fine grained soils except non-plastic silts (ML). For borderline soils requiring dual symbols there may be some difficulty in selecting the proper set of curves. In such cases it may be necessary to plot the points on both sets of curves. If the moisture content is close to optimum the points will plot closer to the line of optimums for the correct set of curves.

(3) Testing Procedure

(3.1) Equipment Required

1 mold: 152.4 mm (6 in.) in diameter or

1 mold: 101.6 mm (4 in.) in diameter

1 Proctor hammer: 2.5 kg (5.5 lbs.) mass

Balances: 25 lb. capacity and 500 g capacity

Drying oven, hot plate or Coleman stove, or a nuclear gauge.

Straight edge and mixing tools

(3.2) A step-by-step procedure of the one point Proctor test is as follows:

(a) *Collect a sample for the OPT*

The mass of the sample should be around 9 kg (20 lbs.). The sample location should be carefully chosen, keeping in mind that the closer the material is to the optimum moisture content, the more accurate the test result will be.

(b) *Replace oversize particles*

If the test portion of the soil contains particles larger than about 25 mm, these should be picked out and discarded. An equal mass of gravel smaller than 25 mm should be added to the sample to replace the larger particles.

(c) *Adjust water content if necessary*

If the test portion is visibly much drier or much wetter than the optimum, water should be added or the sample should be dried out so that the test is carried out on material having moisture content close to the optimum. It is anticipated that water adjustment will be required only in exceptional cases. If the field moisture is altered for the test, the nuclear gauge can no longer be used for moisture determination, consequently conventional drying methods should be used.

(d) *Carry out compaction test in the mold*

The OPT method was designed by using the 152.4 mm diameter mold. It is preferred that this large mold be used for the test, even if the material is fine grained.

For silts and clays, having less than 5% gravel however, the small mold (101.6 mm diameter) may be used if the larger mold is not available. The sample is compacted in the mold (with collar attached) in three equal layers using the 2.5 kg (5.5 lbs.) hammer, falling 30 cm (12 in.). Each layer should receive 56 blows (large mold) or 25 blows (small mold), distributed uniformly over the surface. The final compacted depth should be about 13 cm (5 in.). The collar is then removed, the sample trimmed flush, any surface irregularities are repaired with fresh material and the total mass of mold and soil recorded. The mass of the mold previously recorded is subtracted from the total mass and then is divided by the volume of the mold to obtain the wet density. The volume of the 152.4 mm mold is 2.13 dm^3 (0.075 $ft.^3$), and the 101.6 mm mold is 0.944 dm^3 (0.033 $ft.^3$).

The formula for wet density is:

$$\text{Wet density} = \frac{\text{Mass of soil}}{\text{Vol. of mold}}$$

The wet density is expressed in lbs./$ft.^3$ ($kg/dm^3 = t/m^3$ in metric terms).

(e) Determine moisture content

For the conventional drying method the moisture content of the sample should be determined by the formula:

$$\text{Moisture content} = \frac{\text{(mass of wet soil) - (mass of dry soil)}}{\text{mass of dry soil}} \times 100\%$$

The moisture content is expressed as a percentage.

(f) *Calculate dry density*

The dry density is calculated by the formula:

$$\text{Dry density} = \frac{\text{wet density} \times 100}{100 + \text{moisture content (\%)}}$$

The dry density is expressed in lbs./ft.^{3} or in metric kg/dm^3 which is equal to t/m^3.

The above formula can be simplified to read:

$$\text{Dry density} = \frac{\text{wet density}}{1 + \text{moisture content}}$$

In this formula the moisture content is expressed as a decimal value. (i.e. 13% = 0.13).

(g) *Plot value of dry density and moisture content on the family of Proctor curves*

The point so obtained on the diagram may lie on or near a typical Proctor curve. To obtain the maximum dry density and optimum moisture content corresponding to the particular soil follow upward parallel to the curves to reach the locus of maximum densities. The vertical scale of this point determines the maximum dry density and the horizontal scale the optimum moisture content.

In exceptional cases, a point may fall to the left of the dotted line on the dry side of the curves. In such occasions, the test should be repeated at a higher moisture content. If a point plots to the right of the dotted line on a wet side of the curves, the test should be repeated at a lower moisture content.

(h) *Form PR-CC-10 is used for the calculation of the One Point Proctor Test in the field*

It is good practice to establish the proctor data on the basis of three, one point proctor tests. Figure 4 shows this form.

(4) Example (Metric Units)

Following the compaction of a cohesive soil sample into the 152.4 mm diameter mold, assume the following information.

Mold Volume = 2.13 dm^3

Mass of mold and wet soil = 8.75 kg

Mass of mold = 4.31 kg

Further assume that the moisture content computed by oven drying was 15%.

Calculations:

Moisture

TEST OR TIN No	1
GROSS WET MASS	306.0
GROSS DRY MASS	274.5
(N) MOISTURE LOSS	31.5
MASS OF TIN	64.5
(P) DRY SOIL MASS	210.0
(M) % MOISTURE $\frac{N}{P} \times 100$	15.0

Wet and Dry Densities

(J) VOLUME OF PROCTOR MOULD USED - 2.13

TEST No	1	
MASS OF MOULD & SOIL	8.75	
MASS OF MOULD	4.31	
(K) MASS OF WET SOIL	4.44	
(L) WET DENSITY $\frac{K}{J}$	2.084	
(M) MOISTURE %	* 15.0	*
DRY DENSITY $\left(\frac{L}{100+M}\right) \times 100$	* 1.812	*

* Plot dry density and moisture content on the cohesive family of proctor curves diagram (point 'T' on Figure 5). Follow this point parallel to the curves up to the locus of maximum densities and obtain point 'U'. Read the corresponding maximum dry density on the vertical scale and the optimum moisture content on the horizontal scale.
The values so obtained are: maximum dry density = 1.846 t/m^3
optimum moisture content = 15.8%

(5) Example (Imperial Units)

Following the compaction of a cohesive soil sample into the 6 inch diameter mold assume the following information.

Mold volume = $\frac{1}{13.333}$ cu. ft. = 0.075 ft.^{3}

Mass of mold and wet soil = 19.29 lbs.

Mass of mold = 9.50 lbs.

Further assume that the moisture content computed by drying was 15%.

Calculations:

Moisture

TEST OR TIN No	1
GROSS WET MASS	306.0
GROSS DRY MASS	274.5
(N) MOISTURE LOSS	31.5
MASS OF TIN	64.5
(P) DRY SOIL MASS	210.0
(M) % MOISTURE $\frac{N}{P} \times 100$	15.0

Wet and Dry Densities

(J) VOLUME OF PROCTOR MOULD USED - 0.075

TEST No	1	
MASS OF MOULD & SOIL	19.29	
MASS OF MOULD	9.50	
(K) MASS OF WET SOIL	9.79	
(L) WET DENSITY $\frac{K}{J}$	130.5	
(M) MOISTURE %	* 15.0	*
DRY DENSITY $\left(\frac{L}{100+M}\right) \times 100$	* 113.5	*

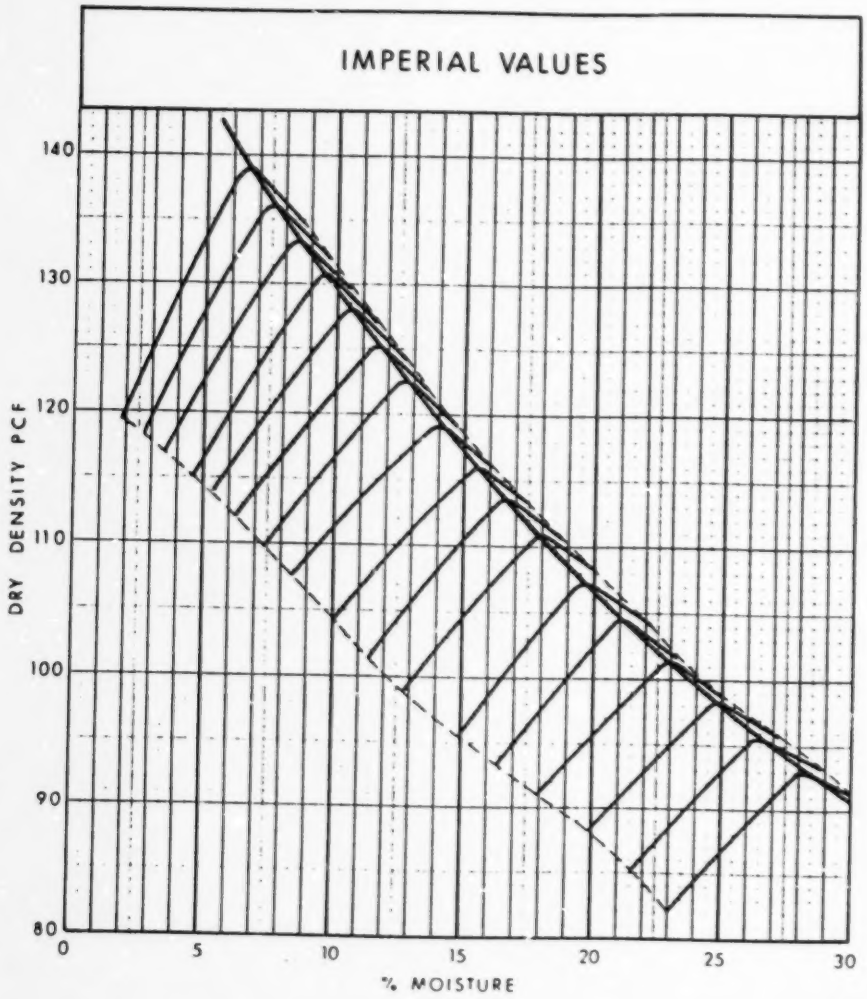
* Plot dry density and moisture content on the cohesive family of proctor curves diagram (point 'R' on Figure 5). Follow this point parallel to the curves up to the locus of maximum densities and obtain point 'S'. Read the corresponding maximum dry density on the vertical scale and the optimum moisture content on the horizontal scale. The values so obtained are: maximum dry density = 115.2 lbs./ft.^{3}

optimum moisture content = 15.8%

TYPICAL MOISTURE - DENSITY CURVES

COHESIVE SOILS IN ONTARIO

(DRY DENSITY CURVES)



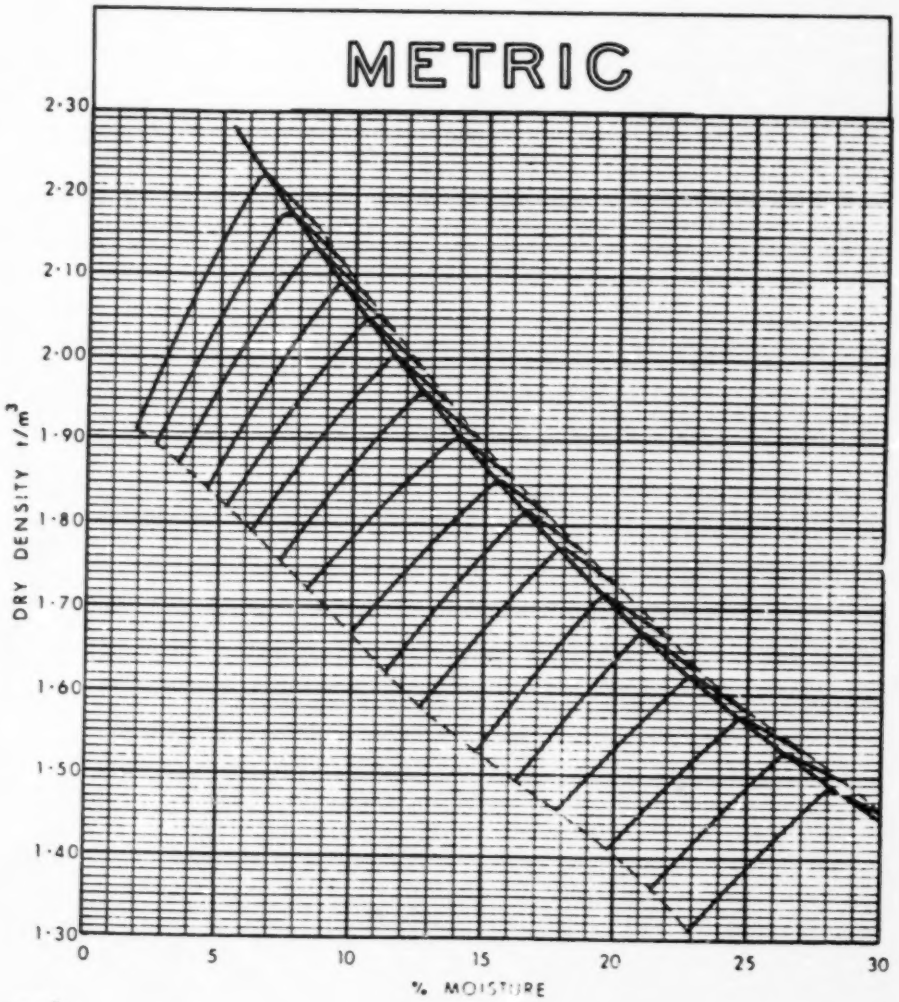


Figure 1

TYPICAL MOISTURE - DENSITY CURVES

NON COHESIVE SOILS IN ONTARIO

(DRY DENSITY CURVES)

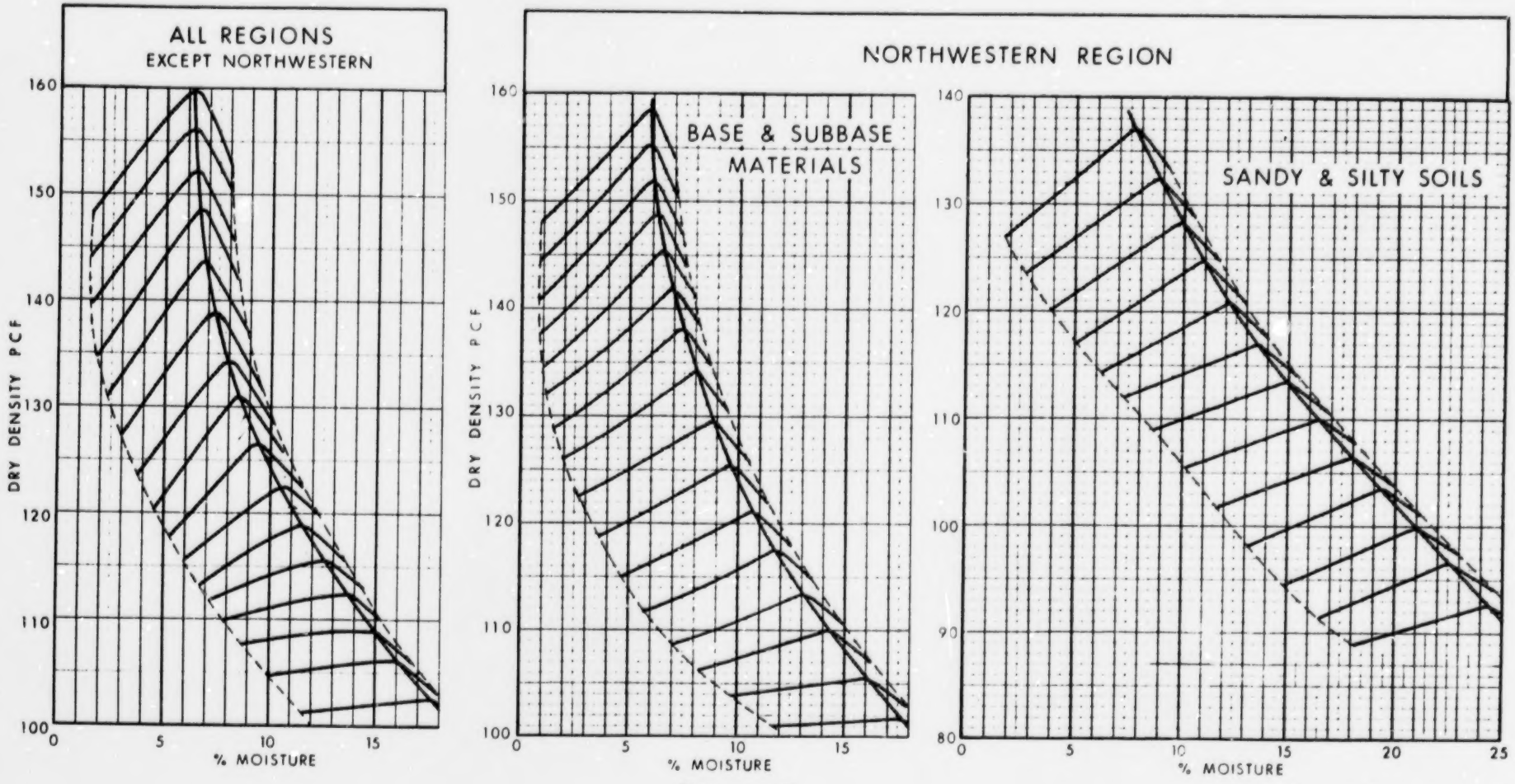


Figure 2

METRIC

TYPICAL MOISTURE-DENSITY CURVES

NON COHESIVE SOILS IN ONTARIO

(DRY DENSITY CURVES)

METRIC

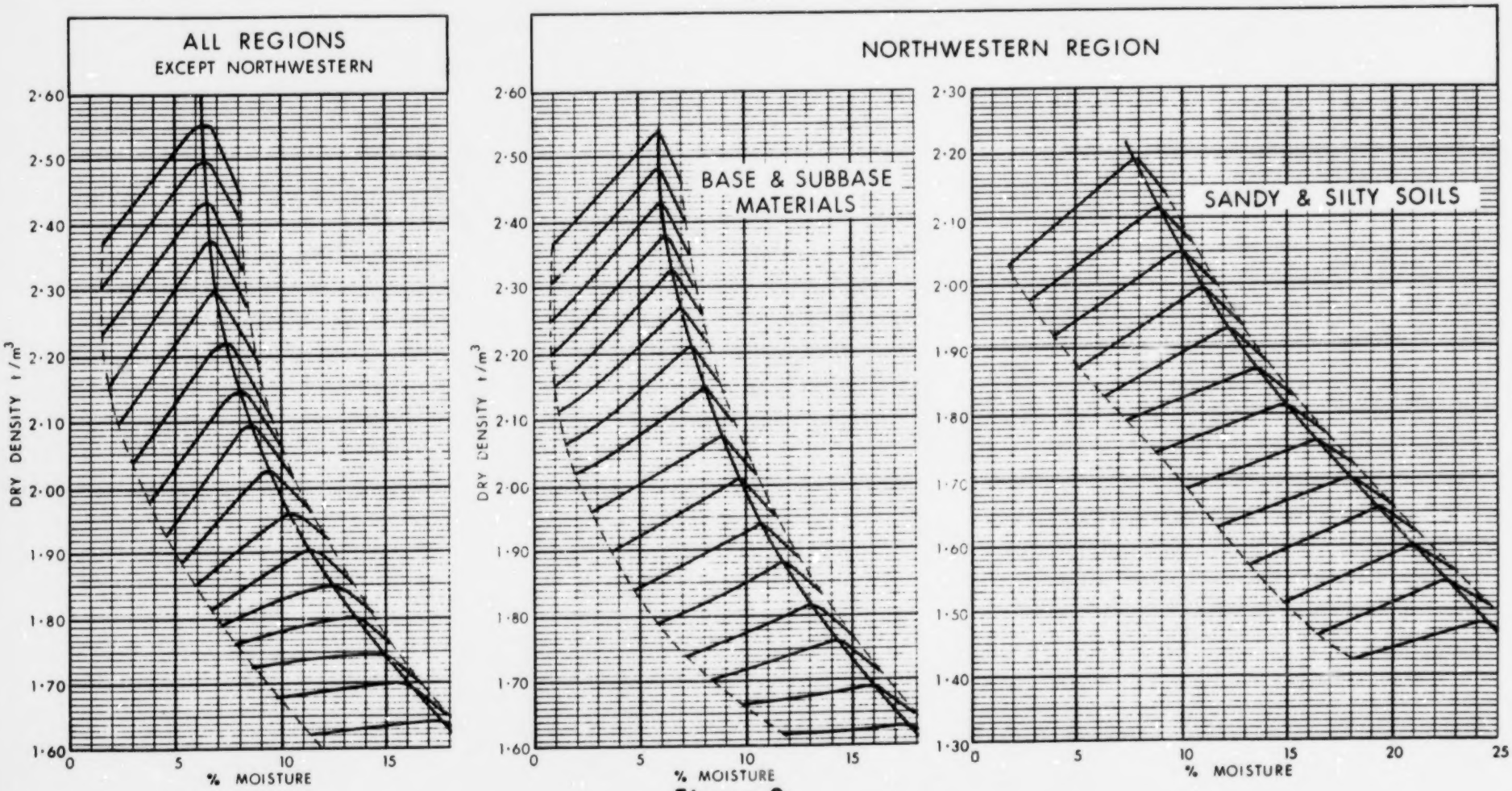


Figure 3

Ministry of Transportation and Communications
Ontario

ONE POINT PROCTOR TEST

CONTRACT No _____

HIGHWAY No _____

REGION _____

TYPE OF MATERIAL _____ SOURCE _____

NUCLEAR MOISTURE DETERMINATION

GAUGE No

REFERENCE STANDARD READING Ⓐ MOISTURE - Ⓑ DENSITY - DATE.

TEST No.	LOCATION		MOISTURE				DENSITY				PROBE POSITION	REMARKS
	STATION	OFFSET	Ⓒ COUNT PER MINUTE	RATIO $\frac{C}{A}$	WATER CONTENT Ⓔ t/m³ (pcf)	Ⓜ % $\frac{E}{F-E}\times 100$	Ⓓ COUNT PER MINUTE	RATIO $\frac{D}{B}$	Ⓕ WET DENSITY t/m³ (pcf)	DRY DENSITY F - E t/m³ (pcf)		

MOISTURE DETERMINATIONS
(IF NUCLEAR GAUGE NOT USED)

TEST OR TIN No			
GROSS WET MASS			
GROSS DRY MASS			
Ⓝ MOISTURE LOSS			
MASS OF TIN			
Ⓟ DRY SOIL MASS			
Ⓜ % MOISTURE $\frac{N}{P}\times 100$			

Ⓙ VOLUME OF PROCTOR MOULD USED -

TEST No			
MASS OF MOULD & SOIL			
MASS OF MOULD			
Ⓚ MASS OF WET SOIL			
Ⓛ WET DENSITY $\frac{K}{J}$			
Ⓜ MOISTURE %	*	*	*
DRY DENSITY $\left(\frac{L}{100+M}\right)\times 100$	*	*	*

OPTIMUM MOISTURE %			
MAX DRY DENSITY			

MAXIMUM WET DENSITY = $\frac{MDD \times (100 + OMC\ \%)}{100}$ =

* NOTE:
Apply these values to the appropriate moisture - density curves to obtain the optimum moisture and maximum dry density for each test.

PROCTOR DATA AVERAGE OF THREE OPT	
OMC %	
MDD	
MWD	

PROCTOR MOULD VOLUMES

LARGE - 152·4 mm (6 in) = 2·13 dm³ $\left(\frac{1}{13\cdot3}\right.$ cu ft$\left.\right)$ 0.075 cu. ft.

SMALL - 101·6 mm (4 in) = 0·94 dm³ $\left(\frac{1}{30}\right.$ cu ft$\left.\right)$ 0.033 cu. ft.

TECHNICIAN: _____

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Figure 4

TYPICAL MOISTURE - DENSITY CURVES

COHESIVE SOILS IN ONTARIO

(DRY DENSITY CURVES)

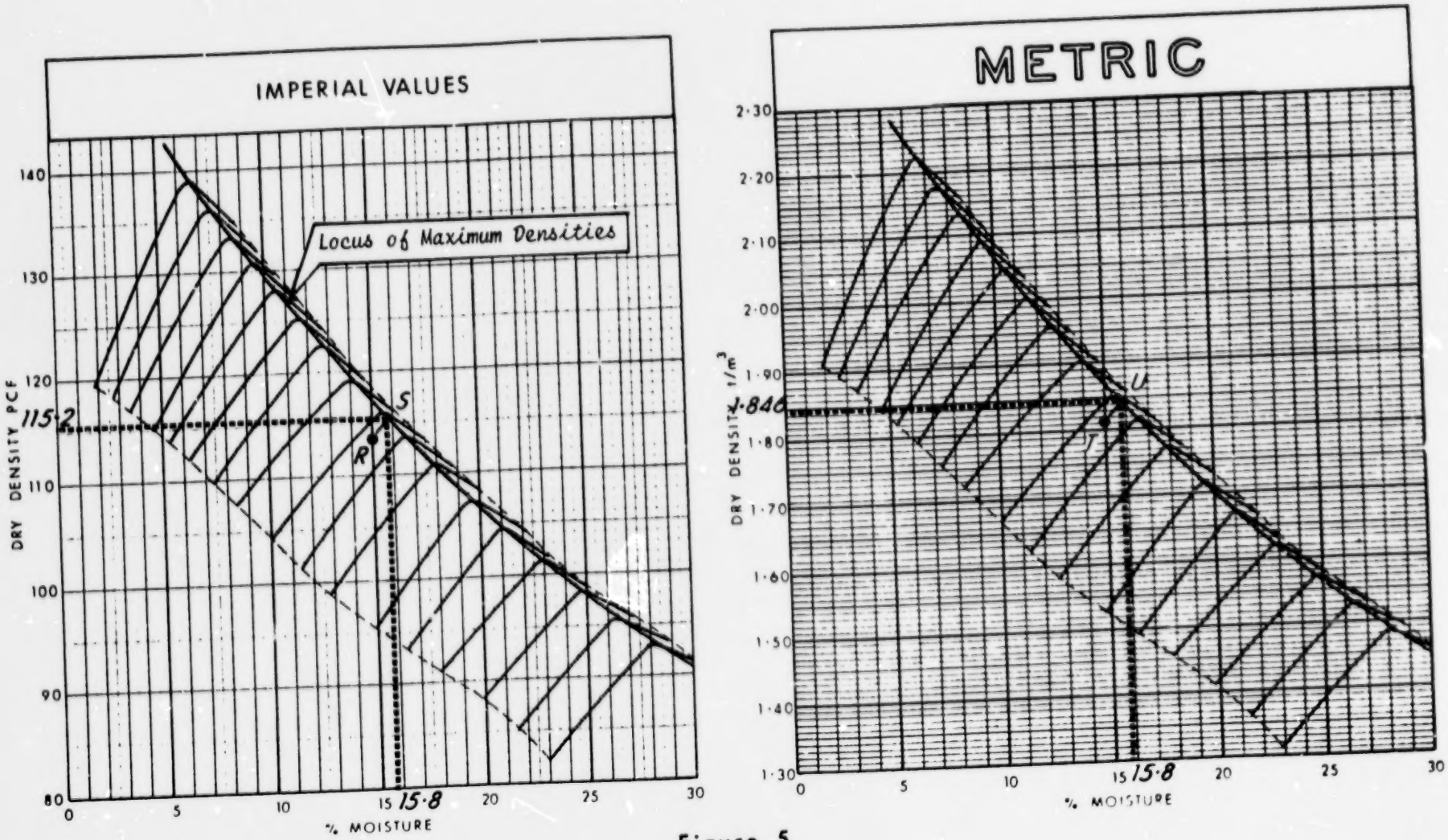

Figure 5